SYSTEM FOR ENHANCED LITHIUM-ION BATTERY PERFORMANCE AT LOW TEMPERATURES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to battery systems and, more particularly, to a battery system adapted for use at varying temperatures.

2. Description of the Prior Art

Present lithium-ion (Li-ion) cells demonstrate low operating efficiency, and a corresponding low discharge capacity, at temperatures below 20° C. While a Li-ion cell may demonstrate a low discharge capacity at a low temperature, it will recover to a normal discharge capacity when the ambient temperature returns to a higher value.

Li-ion cells generate heat during discharge. Therefore, insulating a Li-ion cell during use at low temperatures causes the cell to demonstrate a higher discharge capacity than if it were uninsulated. However, maintaining the insulation on the cell when the cell is used in a higher temperature environment could have negative effects on the cell because of excess accumulation of heat.

Therefore, there is a need for an apparatus that retains heat in Li-ion cells while operating at relatively low temperatures, and that conducts heat from the cells while operating at higher temperatures.

BRIEF DESCRIPTION OF THE FIGURES OF THE DRAWINGS

FIG. 1 is a perspective view of a plurality of prismatic cells in a close packing arrangement.

FIG. 2 is a perspective view of an insulating sleeve according to one embodiment of the invention.

FIG. 3 is a perspective view of the cells shown in FIG. 1 disposed in the sleeve shown in FIG. 2.

FIG. 4 is a perspective view of a plurality of cylindrical cells in a close packing arrangement.

FIG. 5 is a perspective view of an insulating sleeve according to one embodiment of the invention.

FIG. 6 is a perspective view of the cells shown in FIG. 4 disposed in the sleeve shown in FIG. 5.

DETAILED DESCRIPTION OF THE INVENTION

A preferred embodiment of the invention is now described in detail. Referring to the drawings, like numbers indicate like parts throughout the views. As used in the description herein and throughout the claims, the following terms take the meanings explicitly associated herein, unless the context clearly dictates otherwise: the meaning of "a," "an," and "the" includes plural reference, the meaning of "in" includes "in" and "on."

As shown in FIGS. 1-3, one embodiment of the invention is a battery **100** for use in various temperature environments. A plurality **110** of cells **112**, such as lithium-ion cells, are arranged in a close packing arrangement, such as stacked. This arrangement takes advantage of the fact that closely packed cells **112** have less surface area exposed to lower temperature environments than cells arranged, for example, end-to-end. A jacket **120** includes a sleeve **122** that defines a cavity **124** that is complementary in shape to the plurality **110** of cells **112**. The sleeve **122** is disposed around the cells **112**. The sleeve **122** is made from a material that acts as an insulator at relatively low temperatures and that acts as a conductor at relatively high temperatures. Typically, the sleeve **122** is constructed from a phase change material, also referred to as a cool phase material. One illustrative example of a phase change material that has been used in experimental studies of the invention is Coolphase™ MPC-120, available from Thermoset, Lord Chemical Products, 5101 East 65th Street, Indianapolis, Indiana 46220. It has been found that this material works well for single transitions from a cold environment to a warm environment. However, a sleeve **122** made of this material should be replaced after each cold-to-warm temperature transition when multiple transitions occur. While FIG. 3 shows the sleeve **122** wrapped around a stack of cells **112**, individual sleeves could also be wrapped around individual cells **112** without departing from the scope of the invention.

An alternate embodiment, designed for use with cylindrical cells **212** is shown in FIGS. 4-6. The jacket **220** includes a sleeve **222** that defines a cavity **224** into which the cells **212** are placed. A lid **226** made of the phase change material may also be supplied to provide additional insulation.

Li-ion cells self heat during discharge. Such temperature response is attributed to the effect of current on cell polarization and IR impedance. The rate and quantity of heat generation depends on the discharge current and ambient temperature. Unless the heat is dissipated from the cells, the heat becomes available to self heat the cells. The invention

takes advantage of the self heating of lithium ion cells to improve discharge capacity to values higher than presently achieved at low temperatures by uninsulated cells.

This invention allows one type of cell to be manufactured for both cold environments and warm environments. If used in a cold environment, the phase change material acts as an insulator, whereas if used in a warm environment, the phase change material is capable of increasing its thermal conductivity and act as a conductor. With advances in phase change material technology, multiple transitions will be possible, thereby allowing one to go back and forth between the arctic and the tropics with one battery.

The above described embodiments are given as illustrative examples only. It will be readily appreciated that many deviations may be made from the specific embodiments disclosed in this specification without departing from the invention. Accordingly, the scope of the invention is to be determined by the claims below rather than being limited to the specifically described embodiments above.